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RECOMMENDED INTERIM CRITERIA FOR THREE ENVIRONMENTAL POLLUTING COMPOUNDS OF ROCKY MOUNTAIN ARSENAL

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PREPARED FOR
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Interim criteria for the protection of human health were calculated using the formula proposed by the Environmental Protection Agency. The no-observable effect levels (NOELs) for the three pollutants, DIMP, IMPA, and DCPD, were derived from the available toxicological data bases, the Acceptable Daily Intakes (ADIs) calculated and hence the water quality and drinking water criteria values. Recommended interim values (mg/L) are as follows:

	DIMP	IMPA	DCPD
Water quality	9.70	16.75	2.84
Drinking water	9.73	16.80	3.32

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INTRODUCTION

Recommendations for interim environmental criteria are provided in this report as an update of the toxicological and biological data base needed to anticipate future effluent limitations and environmental exposures for contaminant chemicals identified on US Army arsenals and installations. Current pollution abatement and clean-up technologies should be assessed for their ability to meet the estimated effluent standards based on these criteria. Where current technologies are shown to be inadequate, it is anticipated that the US Army Materiel Command (AMC), US Army Toxic and Hazardous Materials Agency (USATHAMA), will initiate appropriate research directed toward filling these technological data gaps.

Environmental criteria have been derived for the following three compounds that have been identified as pollutants in both surface water and sampling wells on land at Rocky Mountain Arsenal, Colorado:[1]

1) Diisopropyl methylphosphonate (DIMP);

2) Isopropyl methylphosphonic acid (IMPA); and

3) Dicyclopentadiene (DCPD).

Additional keywords: data bases; water quality; drinking water; ADI (Acceptable Daily Intake) computations

RECOMMENDED INTERIM ENVIRONMENTAL CRITERIA

The following interim criteria for the protection of human health and aquatic organisms were calculated by use of the methodologies proposed by the US Environmental Protection Agency and published in the Federal Register.[2-7] These are the current federal guidelines for water quality criteria, but it should be recognized that these guidelines are still proposed and may change when finalized. At finalization, the impact (if any) of any changes on the derivation of criteria will have to be assessed.

All the criteria recommended herein are also subject to change when any new scientific data on the compounds of concern become available. It must be emphasized that these numbers are lower than they might be had the dietary content of the compounds been increased to a level closer to an effect level.

The interim criteria (water concentration. mg/L) derived for the protection of human health and of aquatic organisms are as follows:

Water Quality		Drinking Water	
DIMP:	9.70 mg/L	DIMP:	9.73 mg/L
IMPA:	16.75 mg/L	IMPA:	16.80 mg/L
DCPD:	2.84 mg/L	DCPD:	3.32 mg/L

The details of the methodology used are given in full in the following section. The detailed calculations are set out in the appendixes.

DETAILS OF METHODOLOGY USED FOR CALCULATION OF CRITERIA

The methodology used is that established by EPA and published in the Federal Register.[4,7]

1. No-observable effect level (NOEL) calculation for animals

$$\text{NOEL} = \frac{\text{No-effect dietary concentration of test compounds (mg/kg)} \times \text{Daily food or water intake (kg)}}{\text{Body weight of test animal (kg)}}$$

The daily food or water intake and the average body weight of the test animals is taken from the Registry of Toxic Effects of Substances.[8]

2. NOEL conversion from animal to human values

The assumption is made that a plot of d, the no-effect daily dose (mg/day) against body surface area (rather than against body weight) is linear. Since body surface area is approximately proportional to the 2/3 power of body weight, it follows that

$$d_{human}/d_{animal} = (W_H/W_A)^{2/3}$$

and

$$\frac{d_{human}/W_H}{d_{animal}/W_A} = (W_A/W_H)^{1/3}$$

where W_H = average body weight for a human adult, 70 kg

W_A = average body weight for a test animal

Since NOEL = d/W (mg/kg/day)

$$\text{NOEL}_{human} = \text{NOEL}_{animal} \times (W_A/W_H)^{1/3}$$

3. Derivation of the Acceptable Daily Intake (ADI) in mg/kg/day

$$\text{ADI} = \text{NOEL}_{human}/100 = \text{NOEL}_{animal} \times (W_A/W_H)^{1/3}/100$$

The NOEL is converted into an ADI for man by dividing by an uncertainty factor of 100. The guidelines for using the uncertainty factors are given in References 9 and 10.

4. Calculation of the water criteria, C

$$C = \frac{ADI - (DT + IN)}{2 + 0.0065R}$$

where C = water concentration of compound (mg/L)
DT = estimated non-fish dietary intake
IN = estimated daily intake by inhalation
R = bioconcentration factor (units of L/kg)

Calculations of criteria are made using the standard exposure assumptions[7] of 2 liters of water, 6.5 gm of edible aquatic products, and an average body weight of 70 kg for man.

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APPENDIX A - DIMP (DIISOPROPYL METHYLPHOSPHONATE)

MAMMALIAN TOXICOLOGY

A summary of the mammalian toxicology of DIMP has been compiled by Rosenblatt et al.[1] This includes LD50 values by subcutaneous, intraperitoneal, dermal, and intravenous routes of administration to rats, mice, and rabbits.

Contract studies supported by the US Army Medical Research and Development Command fo the purpose of providing a portion of a data base required for recommending environmental criteria have been reported by Hart.[2,3] The results of the following studies have been reported by Dacre and Hart:[4] acute oral LD50s (mg/kg with 95% confidence limits) in rats [males, 1,125 (903-1,201), females, 826 (747-914)] and mice [males, 1,041 (903-1,201), females, 1,363 (1,165-1,594)], skin and eye irritation in rabbits, skin sensitization in guinea pigs, and subchronic feeding in dogs (16 days at levels of 150, 500, and 1,500 ppm), in rats (90 days at levels of 300, 1,000, and 3,000 ppm), and in mice (90 days at levels of 210, 700, and 2,100 ppm). Reports of the following studies by Hart[3] are available: Ames microbial assay, teratology in rats, three-generation reproduction studies in rats and 90-day subchronic toxicity in dogs (dose levels of 150, 1,500, and 3,000 ppm), and demyelination in chickens.

The following contract studies have also been reported: aquatic organisms (Bentley et al.[5]); Mallard ducks, bobwhite quail, and mink (Aulerich et al.[6]); cattle (Palmer et al.[7], Cysewski et al.[8]), the lactating cow (Ivie[9]), and phytotoxicity (O'Donovan and Woodward[10]).

Additional studies on DIMP have also been carried out by Chemical Systems Laboratory, Aberdeen Proving Ground, MD. Hardisty et al.[11] reported on a reproductive study in rats and Biskup et al.[12] reported on a 26-week toxicity study in rats dosed with DIMP in the drinking water.

In all of these experiments, no evidence of toxicity other than LD50 was found. The highest NOEL values used for the determinaton of the ADI are 3,000 ppm in the diet (90-day dog study), 3,000 ppm in the diet (90-day rat study), and 2,100 ppm in the diet (90-day mouse study).

CALCULATION OF A WATER QUALITY CRITERION

A water quality criterion value for DIMP is calculated according to the formula and methodology as published in the Federal Register (E.P.A.[13,14]) assuming an average ingestion of 6.5 g of fish per day:

1. Dogs:

$$NOEL_{animal} = 3{,}000 \text{ mg/kg in the feed} \times 0.25 \text{ kg feed per day}/10 \text{ kg body weight}$$

$$= 75 \text{ mg}/(\text{kg} \times \text{day})$$

$$ADI = \frac{75 \text{ mg/(kg x day)} \ (15 \text{ kg}/70 \text{ kg})^{1/3}}{100} = \frac{75 \times 0.6}{100}$$

$$= 0.45 \text{ mg/(kg x day)}$$

$$C = \frac{0.45 \times 70}{2 + (1 \times 0.0065)}$$

$$= 15.70 \text{ mg/L}$$

$$C \text{ (drinking water)} = \frac{0.45 \times 70}{2} = 15.75 \text{ mg/L}$$

[Note: The ratio 0.25 kg feed per day per 10 kg dog was used to estimate $NOEL_{animal}$. The experimental average animal weight of 15 kg was used to calculate ADI.]

2. Rats:

$NOEL_{animal}$ = 3,000 mg/kg in the feed x 0.01 kg feed per day/0.2 kg body weight

$$= 150 \text{ mg/(kg x day)}$$

$$ADI = \frac{150 \text{ mg/(kg x day)} \ (0.3 \text{ kg}/70 \text{ kg})^{1/3}}{100} = \frac{150 \times 0.16}{100}$$

$$= 0.24 \text{ mg/(kg x day)}$$

$$C = \frac{0.24 \times 70}{2 + (1 \times 0.0065)}$$

$$= 8.37 \text{ mg/L}$$

$$C \text{ (drinking water)} = \frac{0.24 \times 10}{2} = 8.40 \text{ mg/L}$$

[Note: The ratio 0.1 kg feed per day per 0.2 kg female rat was used to estimate $NOEL_{animal}$. The experimental average animal weight of 0.3 kg was used to calculate ADI.]

3. Mice:

NOEL = 2,100 mg/kg in the feed x 0.003 kg feed per day/0.025 kg body weight

$$= 252 \text{ mg/(kg x day)}$$

$$ADI = \frac{252 \times (0.035\ kg/70\ kg)^{1/3}}{100} = \frac{252 \times 0.0793}{100}$$

$$= 0.199\ mg/(kg \times day)$$

$$C = \frac{0.199 \times 70}{2 + (1 \times 0.0065)}$$

$$= 6.94\ mg/L$$

$$C\ (drinking\ water) = \frac{0.199 \times 70}{2} = 6.97\ mg/L$$

[Note: The ratio 0.003 kg feed per day per 0.025 kg mouse was used to estimate $NOEL_{animal}$. The experimental average animal weight of 0.035 kg was ussed to calculate ADI.]

In all these calculations:

DT = 0 (It is assumed that there are no non-fish dietary sources)

IN = 0 (It is assumed that the vapor pressure is too low for vapor inhalation to be significant and that no inhalable dust at the contamination site has a significant loading of DIMP

R = 1 (See Reference 5)

The geometric means of the criteria values are 9.70 for water quality and 9.73 for drinking water.

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APPENDIX B - IMPA (ISOPROPYL METHYLPHOSPHONIC ACID)

MAMMALIAN TOXICOLOGY

A summary of the physical and chemical properties of IMPA has been compiled by Rosenblatt et al.;[1] no data were found on mammalian toxicology.

Contract studies supported by the US Army Medical Research and Development Command for the purpose of providing a portion of a data base required for recommending environmental criteria have been reported by Mecler.[2] The results of the following studies have been reported by Mecler and Dacre:[3] acute oral LD50s (mg/kg with 95% confidence limits) in rats [males, 7,650 (6,560-8,920), females, 6,070 (4,760-7,740)] and mice (males, 5,620 (4,530-6,990), females, 6,550 (5,140-8,360)], acute dermal toxicity in rabbits, skin sensitization in guinea pigs. Ames mutagen assay, and subchronic toxicity cover a period of 90 days in rats.

Rats which received 300, 1,000, or 3,000 ppm of sodium IMPA in the drinking water for 90 days exhibited no signs of toxicity when compared to the controls. Clinical hemotology and chemistry, as well as histopathologic evaluation of tissues taken at necropsy, revealed no adverse effects. Hence, IMPA has a low degree of toxicity and the highest level administered, i.e. 3,000 ppm, was the NOEL used to calculate the ADI.

CALCULATION OF A WATER QUALITY CRITERION

Water quality criterion value for IMPA is calculated according to the formula and methodology as published in the Federal Register (E.P.A.[4,5]) assuming an average ingestion of 6.5 g of fish per day,

Rats:

$$NOEL_{animal} = 3{,}000 \text{ mg/kg in the drinking water} \times 0.02 \text{ kg water per day}/0.2 \text{ kg body weight}$$

$$= 300 \text{ mg}/(\text{kg} \times \text{day})$$

$$ADI = \frac{300 \times (0.3 \text{ kg}/70 \text{ kg})^{1/3}}{100} = \frac{300 \times 0.16}{100}$$

$$= 0.48 \text{ mg}/(\text{kg} \times \text{day})$$

$$C = \frac{0.48 \times 70}{2 + (1 \times 0.0065)}$$

$$= 16.75 \text{ mg/L}$$

$$C \text{ (drinking water)} = \frac{0.48 \times 70}{2} = 16.80 \text{ mg/L}$$

[Note: The ratio 0.02 kg water per day per 0.2 kg female rat was used to estimate $NOEL_{animal}$. The experimental average animal weight was used to calculate ADI.]

In the calculation:

DT = 0 (It is assumed that there are no non-fish dietary sources)

IN = 0 (It is assumed that the vapor pressure is too low for vapor inhalation to be significant and that no inhalable dust at the contamination site has a significant loading of IMPA)

R = 1 (Assumed value, since IMPA is very polar and since it exists as an anion it will not accumulate in the fat of fish.)

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APPENDIX C - DCPD (DICYCLOPENTADIENE)

MAMMALIAN TOXICOLOGY

A summary of the mammalian toxicology of DCPD has been compiled by Rosenblatt et al.[1] This includes LD50 values by oral, intraperitoneal, dermal, and inhalation routes of administration to rats, mice, and rabbits.

Contract studies supported by the US Army Medical Research and Development Command for the purpose of providing a portion of a data base required for recommending environmental criteria have been reported by Hart.[2,3] The results of the following studies have been reported by Hart and Dacre:[4] acute oral LD50s (mg/kg, with 95% confidence limits) in rats [males, 520 (420-645), females, 378 (303-473)] and mice [males, 190 (125-289), females, 250 (170-368)], skin and eye irritation in rabbits, skin sensitization in guinea pigs, and subchronic feeding in dogs (16 days at levels of 40, 125, and 375 ppm), in rats (90 days at levels of 80, 250, and 750 ppm, and in mice (90 days at levels of 28, 91, and 273 ppm). Reports of the following studies by Hart[3] are available: Ames microbial assay, teratology in rats, three generation reproduction studies in rats and 90-day subchronic toxicity in dogs (dose levels of 100, 300, and 1,000 ppm). The following contract studies have also been reported: aquatic organisms (Bentley et al.[5]); mallard ducks, bobwhite quail, and mink (Aulerich et al.[6]); cattle (Palmer et al.[7], Cysewski et al.[8]), the lactating cow (Ivie and Oehler[9]), and phytotoxicity (O'Donovan and Woodward[10]).

In all of these experiments, no evidence of toxicity other than LD50 was found. The highest NOEL values used for the determination of the ADI are 1,000 ppm (90-day dog study) and 750 ppm (90-day rat study).

CALCULATION OF A WATER QUALITY CRITERION

Water quality criterion value for DCPD is calculated according to the formula and methodology as published in the Federal Register (E.P.A.[11,12]) assuming an average ingestion of 6.5 g of fish per day.

1. Dogs:

$$NOEL_{animal} = 1{,}000 \text{ mg/kg in the feed} \times 0.25 \text{ kg feed per day} / 10 \text{ kg body weight}$$

$$= 25 \text{ mg/(kg} \times \text{day)}$$

$$ADI = \frac{25 \text{ mg/(kg} \times \text{day)} \ (15 \text{ kg}/70 \text{ kg})^{1/3}}{100} = \frac{25 \times 0.60}{100}$$

$$= 0.15 \text{ mg/(kg} \times \text{day)}$$

$$C = \frac{0.15 \times 70}{2 + (53 \times 0.0065)}$$

$$= 4.48 \text{ mg/L}$$

$$C \text{ (drinking water)} = \frac{0.15 \times 70}{2}$$

$$= 5.25 \text{ mg/L}$$

[Note: The ratio 0.25 kg feed per day per 10 kg dog was used to estimate $NOEL_{animal}$. The experimental average animal weight of 15 kg was used to calculate ADI.]

2. Rats:

$NOEL_{animal}$ = 750 mg/kg in the feed x 0.01 kg feed per day/0.2 kg body weight

$$= 37.5 \text{ mg/(kg x day)}$$

$$ADI = \frac{37.5 \text{ mg/(kg x day)} \ (0.3 \text{ kg}/70 \text{ kg})^{1/3}}{100} = \frac{37.5 \times 0.16}{100}$$

$$= 0.06 \text{ mg/(kg x day)}$$

$$C = \frac{0.06 \times 70}{2 + (53 \times 0.0065)}$$

$$= 1.80 \text{ mg/L}$$

$$C \text{ (drinking water)} = \frac{0.06 \times 70}{2}$$

$$= 2.10 \text{ mg/L}$$

[Note: The ratio 0.1 kg feed per day per 0.2 kg female rat was used to estimate $NOEL_{animal}$. The experimental average animal weight of 0.3 kg was used to calculate ADI.]

In all these calculations:

DT = 0 (It is assumed that there are no non-fish dietary sources)

IN = 0 (It is assumed that the vapor pressure is too low for vapor inhalation to be significant, and that no inhalable dust at the contamination site has a significant loading of DCPD)

R = 53 (See Reference 5)

The geometric means of the criteria values are 2.84 for water quality and 3.32 for drinking water.

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